IMPLEMENTATION OF PROCESS/EQUIPMENT CHANGES TO REDUCE METAL HYDROXIDE/MIXED SLUDGE DISPOSAL AT TINKER AFB

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ABSTRACT

The industrial wastewater treatment plant (IWTP) at Oklahoma City Air Logistics Center (OC-ALC), located at Tinker AFB, produces a "mixed sludge" as a result of treatment of wastewater to remove organic, heavy metal, and other contaminants. This sludge is disposed as a hazardous sludge at a cost averaging $250,000/yr over the last 3 years. To reduce the cost of sludge disposal as well as to meet P2 goals of reducing off-site waste discharges, Tinker AFB initiated a program three years ago to develop and demonstrate suitable processes and equipment changes to achieve these goals. The program was successfully completed earlier this year and it exemplifies compliance through P2 approach.

An analysis of the IWTP operation revealed that the metals treatment section of the plant was using high dosages of chemicals leading to formulation of large volumes of sludge as well as producing poor quality effluents. To address these problems, two different process chemistries were evaluated and changes in equipment and operating procedures were examined. The $FeSO_4/NaOH$ process was replaced with the $NaHS/FeSO_4$ process to reduce the formation of sludge by about a factor of about two. Additionally, the operating procedures were refined to avoid adding excessive quantities of NaHS and $FeSO_4$. To utilize these new operating procedures, some equipment changes were made to better control chemical additions. Finally, a new process for sludge handling was adapted to further reduce the quantity of sludge disposal.

Full-scale trials of process/equipment changes, completed in January 1998, showed that the quantity of sludge disposed could be reduced by over 60 percent, saving over $170,000 per year. The effluent water quality has been improved and chemical costs have declined. The plant is continuing to practice the process/equipment changes. Recommendations for future improvements were also made. The process changes are applicable at a DoD-wide level.

INTRODUCTION AND BACKGROUND

OC-ALC is committed to reducing the amount of hazardous waste discharged off-site by 50 percent by CY99 relative to CY92 baseline. A key contributor of hazardous waste is the mixed sludge produced in the IWTP. This sludge, an F-waste, is a mixture of metal hydroxide

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sludge from metals treatment section of the IWTP and biosludge from the BOD reduction section of the IWTP. During the last three years (FY's 95, 96, and 97), OC-ALC disposed an average of 1.12×10^6 lbs/yr of thickened (about 10 percent solids), mixed sludge and 0.37×10^6 lbs/yr of de-watered (about 30 percent solids), mixed sludge. The average total disposal cost for these sludges was $249,000/yr. The reason for disposal of a large amount of non-dewatered sludge was that the filter press operation was unsatisfactory.

The IWTP typically receives and treats 900,000 gallons per day of wastewater. The key unit operations in the IWTP are: (a) oil/water separation, (b) metals reduction and precipitation, (c) biotreatment for removal of organics, (d) thickening, conditioning, and dewatering/filtration of a mixture of metal hydroxide sludge and biosludge, and (e) pH adjustment and final filtration of the treated wastewater. The objective of this two-phase project was to identify, develop, and demonstrate suitable process and equipment changes in operations (b) and (d) to cost-effectively reduce the quantity of sludge disposed.

APPROACH

The approach consisted of two steps. First, the relevant processes and equipment were monitored and evaluated along with some exploratory bench- and pilot-scale testing. The preferred process/equipment changes were then evaluated at full-scale and implemented. Battelle worked closely with numerous OC-ALC staff during the implementation phase.

The IWTP operations evaluated included three chemical addition basins, two solids contact clarifiers (SCCs), and a sludge conditioning/dewatering system. Liquid samples were taken at the feed to metals treatment section and at the discharge of the SCCs. These samples were analyzed for oil and grease (O&G), RCRA metals, and total suspended solids (TSS). These analyses provided data to determine the performance of the new metals treatment process. Jar testing was performed to duplicate the process and to determine the effect of various chemical addition rates and the impact of various polymers on the generation of flocs and water turbidity. Solid samples were taken from the sludge holding tank and from the filter press after filtration/dewatering.

Observations of the IWTP were made and information was gathered from interviews with plant operators from each shift. Design information, written plant operating procedures and manuals, and operating data were reviewed. This information established baseline operational procedures, and was used with background knowledge of typical unit operation performance in wastewater treatment service to determine potential changes that could be made to improve plant operation and performance.

During the exploratory testing phase, jar testing was conducted to screen polymers that would improve the water turbidity and improve settling of the solids in the SCC. Several other process/equipment changes to improve metals treatment were evaluated. And pilot plant tests were carried out using improved sludge dewatering methods. During the process/equipment implementation phase, several equipment changes for metals treatment and sludge dewatering were made and the process/equipment changes were evaluated. Based on the results of the full-scale testing and other analyses, a revised operating procedure for metals treatment and mixed sludge dewatering was developed.

IMPROVEMENTS IN METALS TREATMENT

At the beginning of the Phase II effort, the metals treatment section of the IWTP (a) was using high dosages of chemicals, including polymers, (b) had a high effluent turbidity, and (c) was producing excessive amounts of metal hydroxide sludge. To address these problems, OC-ALC and Battelle evaluated and adapted an alternative metal precipitation chemistry and improved chemical and polymer addition process and equipment.

Alternative Chemistry

The existing process for removal of hexavalent chromium (Cr^{VI}) and other RCRA metals was based on the $FeSO_4$/NaOH chemistry. This process operated at a pH of about 9.5 which, on a theoretical basis, requires 3 moles of $FeSO_4$ for every mole of Cr^{VI}. This not only produces a large amount of $Fe(OH)_3$ sludge but also requires neutralization of the treated water. This process also requires a FeS treatment system downstream for achieving low levels of Cr^{+3} in the effluent. The alternative chemistry, on the other hand, consists of using a combination of NaHS and $FeSO_4$ at a near-neutral pH. The theoretical amount of sludge thus produced is roughly 43 percent of the sludge produced in the previous process(1). The need for polishing treatment for Cr^{+3} is also avoided as the use of iron salts in the new process results in complexation reaction with other metals, such that lower than theoretical metal solubilities based on hydroxide alone or sulfide alone processes can be achieved. Thus, the process is simplified. Therefore, the plant was switched over to the new chemistry. Both the jar tests and full-scale tests showed all metals of concern to be below allowed discharge limits. Similar results have been reported in a previous Air Force Study(1) in 1988 and more recently in a study by the Navy(2).

As the influent metal concentrations have greatly declined since the IWTP was designed, it was necessary to make adjustment in chemical feed rates. Based on jar tests, a new set of feed rates were established to achieve the required effluent quality as well as to maintain an active sludge blanket for capturing the precipitated hydroxide particles. It also was necessary to switch to smaller chemical metering pumps to avoid overdosing.

Flocculation Improvements

While the new metals precipitation chemistry produces less sludge, on a dry basis, it requires more attention to flocculation because of the finer nature of the precipitate formed. In particular, it was necessary to avoid overdosing of polymers as well as to properly condition the two polymers. A combination of cationic (Betz 1195) and anionic (Drew 270) polymers was satisfactorily demonstrated with the new chemistry.

Two new polymer blending/conditioning systems were installed and tested for minimizing polymer use and for better control of the polymer feed rates. An alternative polymer combination of PP1075 (cationic) and Drew 270 (anionic) was also satisfactorily tested and specified as a backup.

Both polymer systems helped reduce the effluent suspended solids (TSS) levels from as high as 17 ppm to about 5 ppm. This reduced the overloading and consequently the frequent backwashing of the multi-media pressure filters. These backwash solids eventually settle in the equalization basins ahead of the metals treatment and make a voluminous sludge. In fact, it is estimated that a 1 ppm reduction in effluent TSS reduces equalization basin sludge disposal cost by \$12.10/day. The cost of either polymers system was about a third of this. Furthermore, the reduction in backwashing frequency helped reduce plant operator attention to this operation.

IMPROVED SLUDGE DEWATERING

An analysis of the sludge conditioning and filter press operation showed that much improvement was needed to more completely and reliably dewater the sludge. The existing operation employed a cumbersome $FeCl_3$/lime sludge conditioning process and caused frequent filter cloth blinding. An alternative conditioning process based on the use of perlite, a naturally occurring filter aid was identified. After extended pilot testing, the process was implemented on full-scale. To minimize operator involvement, the process of perlite loading and feeding was simplified and mechanized (Figure 1).

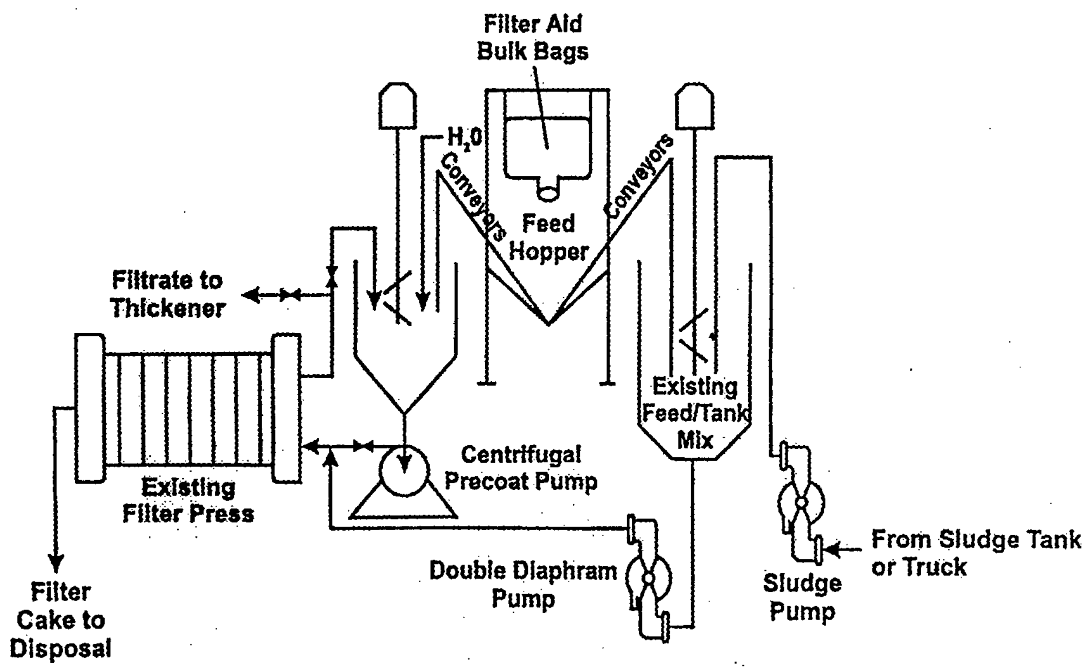

Figure 1 Sludge Dewatering Process Flow Diagram.

The results of seven sludge dewatering tests are summarized in Table 1. The first three tests confirmed that the use of a perlite precoat improved the $FeCl_3$/lime treatment process by reducing filter blinding. The last four tests confirmed that the $FeCl_3$/lime process could be eliminated by use of perlite as a body feed. The typical range for filter cake solids content was 30 to 40 percent, with the feed sludge being at 6 to 14 percent solids. Based on these results, OC-ALC decided to replace the $FeCl_3$/lime treatment process with the simple perlite addition.

An economic analysis of the previous and the new processes was performed. At a perlite precoat rate of 0.033 lb/gallon of feed and a perlite body feed rate of 0.18 lb/gallon of feed, the cost savings are estimated to be $170,000/yr. At a capital cost investment of $175,000, this provides a payback period of about 12 months. The corresponding reduction in off-site sludge disposal weight, even if we assume that metal precipitating chemistry changes do not significantly reduce the amount of metal hydroxides formed, is estimated to be 62 percent.

It was determined that this improved sludge conditioning/dewatering system could also be used to dewater an oily sludge, which until now had been disposed without any dewatering. Thus, the same investment in capital cost also has the potential of saving about $380,000/yr for oily sludge disposal. This potentially reduces the payback period to 4 months.

TABLE 1. FULL-SCALE SLUDGE CONDITIONING/DEWATERING TESTS

	Test Conditions				Total Suspended Solids (TSS) wt.%		
Test No.	**Gallons of Sludge Dewatered**	**$FeCl_3$/lime Treatment**	**Precoat lb/gallon Sludge**	**Perlite Body Feed, lb/gallon Sludge**	**Feed**	**Filter Cake**	**Comments**
1	3,000	Yes	0.033	0.58	14.08	29.70	
2	3,000	Yes	0.033	0.58	11.30	36.23	
3	3,000	Yes	0.05	0.58	ND	38.09	
4	3,000	No	0.05	0.40	10.53	34.13	
5	10,000	No	0.015	0.18	ND	43.40	Mixed with some oily-sludge
6	10,000	No	0.015	0.18	ND	32.20	Mixed with some oily-sludge
7	10,000	No	0.015	0.18	6.20	29.10	Mixed with some oily-sludge

ND: Not determined.

CONCLUSIONS

This project demonstrated that substantial compliance cost savings can be achieved through suitable process and equipment changes. Specifically, (a) the use of $NaHS/FeSO_4$ for Cr^{VI} and metals precipitation, (b) optimization of chemical and polymer feeding, and (c) the use of perlite as a filter aid as well as a body feed was successfully implemented. The overall IWTP operation was simplified and the quantity of sludge disposed was cost-effectively reduced by at least 62 percent.

REFERENCES

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